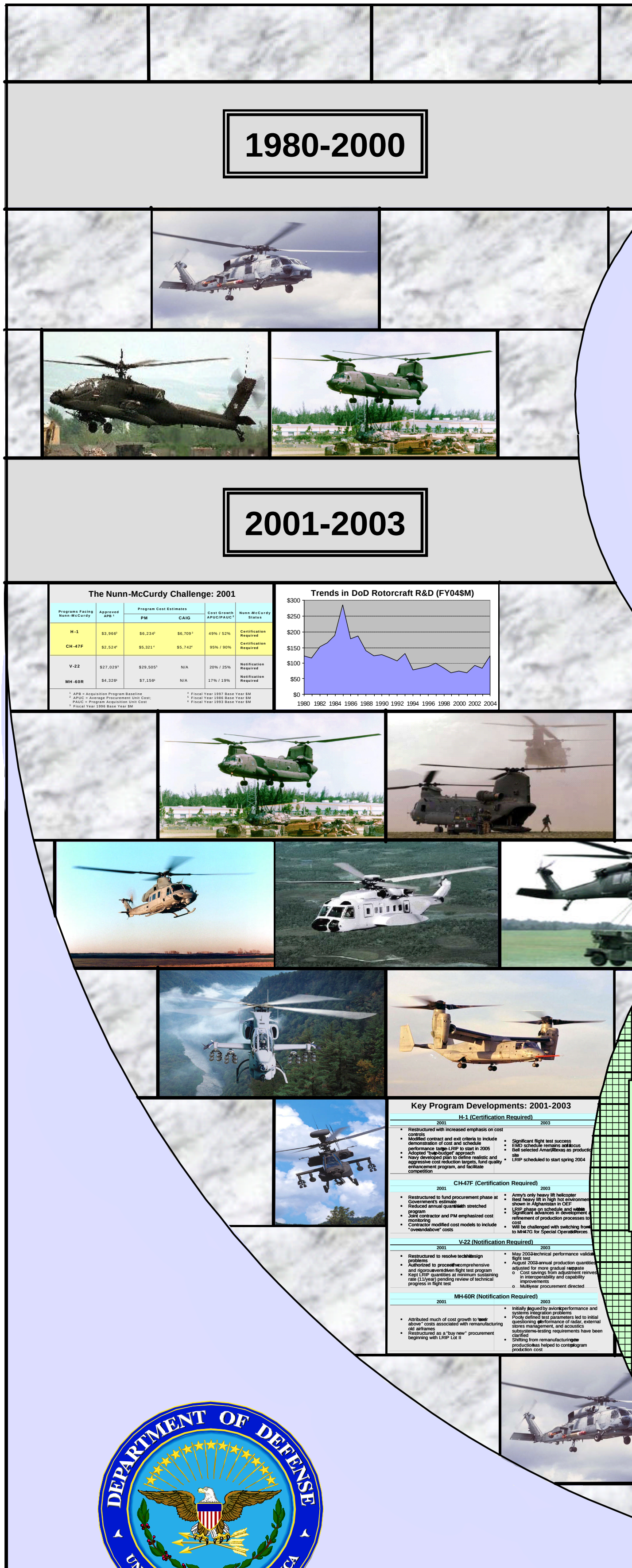
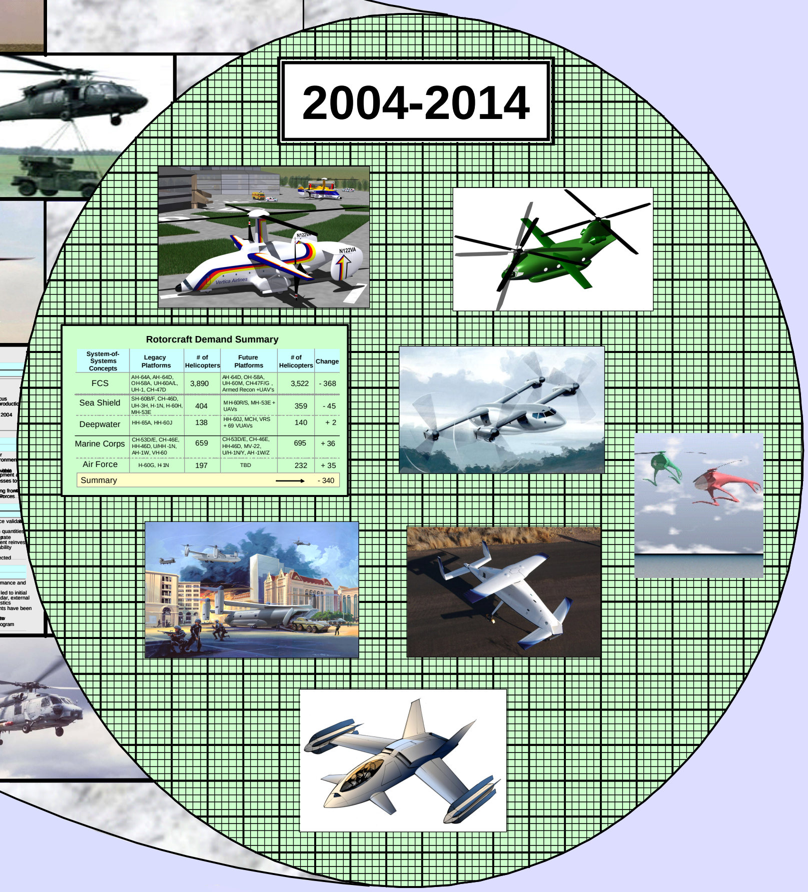


The Vertical Lift Industrial Base: Outlook 2004-2014



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The cover graphic depicts the evolution of vertical lift platforms over the past 25 years and focuses on future capability requirements that will draw on the vertical lift industrial base. At the turn of the century, four of only five Department-wide helicopter acquisition programs experienced Nunn-McCurdy cost breaches. This event highlighted to the Department and the vertical lift industrial base cost and manufacturing issues associated with this sector. At the same time, the extensive use of helicopters in the Global War on Terrorism emphasized their utility—but also their limitations. As the Department transitions to a functional capability, system-of-systems philosophy, new demands will be placed on vertical lift assets. The Department, in conjunction with our industry partners, is at a critical juncture requiring a dedicated commitment that will ensure consolidation of available and new innovative technology into future vertical lift designs. This focus on innovative new designs will best enable the 21st century warfighting capabilities envisioned by these functional concepts and system-of-systems programs.

The term vertical lift is used in this study to highlight its focus on the broadest possible array of technologies and design solutions making use of other than fixed-wing craft. This would include tilt-rotor, tilt-wing, and other advanced configurations. Where "helicopter" is used, it typically refers to the current helicopter suppliers or historical context. Rotorcraft is used only when discussing future vertical lift vehicles that use rotors as their lifting mechanism.

This report and all appendices can be viewed online and downloaded at:

http://www.acq.osd.mil/ip

This report was produced for the Under Secretary of Defense (Acquisition, Technology, & Logistics) by the Deputy Under Secretary of Defense (Industrial Policy) from October 2003-June 2004. Stephen Thompson of the Industrial Policy staff led this effort. Michael Caccuitto and Dawn Vehmeier of the Industrial Policy staff, Mike Walsh of the Defense Systems staff, and Jim Woolsey of IDA also had major roles in the production of this report. Support was provided under contract by First Equity Development, Inc. Among others, special thanks are due to Matthew Mejia of First Equity for his important contributions.

The team would especially like to acknowledge the contributions of Sikorsky, Bell, and Boeing who provided us with data; company site visits; and valuable insights as members of one of this report's Red Teams. Inquiries regarding the report should be directed to Stephen Thompson at (703) 602-4331.

THE VERTICAL LIFT INDUSTRIAL BASE: OUTLOOK 2004-2014

OFFICE OF THE DEPUTY UNDER SECRETARY OF DEFENSE
(INDUSTRIAL POLICY)

JULY 2004

METHODOLOGY

Survey manufacturing and business practices of the U.S. helicopter industry. Provide site-specific and comparative analyses.

Characterize the impact of the new functional capabilities construct and key major programs on vertical lift demand from 2004-2014.

Highlight major challenges and opportunities facing the vertical lift industry and the Department.

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FOREWORD

This report expands and updates important analysis done in the Department in 2001 as a result of Nunn-McCurdy breaches in major helicopter programs. Since then, companies affected by Nunn-McCurdy breaches have made major improvements in manufacturing processes and cost control. However, questions remain as to the innovativeness of this industrial base and its ability to design the manned and unmanned rotorcraft required for transformational systems-of-systems such as the Future Combat System (FCS) and Sea Power 21. These concepts will use vertical lift assets in new roles and demand innovation not currently produced by the defense industrial base.

The Department has major near-term opportunities to stimulate the innovative potential in this industrial base if it chooses to break the paradigm of returning to legacy platforms for new requirements. The Air Force faces an opportunity to stimulate this innovation and new platform design potential through its acquisition of personnel recovery, Air Force Space Command, and Air Mobility Command vertical lift aircraft requirements. The Army and Navy should also challenge the vertical lift industrial base to develop futuristic concepts for the manned and unmanned vertical lift aircraft associated with FCS and Sea Basing. The Military Services' commitment to answer 21st century capability requirements with 21st century designs will inspire investments in these areas. Science and technology investments in vertical lift are imperative to foster development of new platforms that will be essential enablers of the new functional capabilities required for 21st century American warfare.

Without this investment, the robustness of the current earnings outlook for vertical lift suppliers as they refurbish, refit, and remanufacture legacy helicopters may not compel industry to focus on innovation destined for the second or third decade of this century. However, not to focus on these 21st century requirements could cede the most technologically challenging work in rotorcraft applications to new entrants or to the global industrial base.

In addition, Department and Military Service complacency in demanding that new platforms be developed is starving the industry and the warfighter of imaginative concepts important for future operations. Much innovation is undoubtedly broadly distributed throughout industry in commercial vertical lift programs. Incremental innovation also benefits individual platforms as they are repaired or remanufactured. But new program competitions are the only way to elicit and consolidate the best ideas from the broadest possible offerings of the industrial base to benefit the warfighter.

We are encouraged that recognition of this imperative is spreading at senior levels of Department and Military Service leadership. The Army's Aviation Modernization Strategy is capturing many of the important lessons learned in the Global War on Terrorism relating to access denial issues and the utility of vertical lift in ever more dynamic battlefield conditions. Various Department-level task force and roadmap initiatives should provide important vectors with which industry will be able to align its

investment efforts. Finally, the consideration of a Joint Vertical Lift Program Office to synergize near-term requirements into a series of competitions for a family of new vertical lift aircraft will help refocus the Department on the industrial base implications of program acquisition strategies.

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RED TEAMS

Industry

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Lieutenant General (retired) Terrence Dake, USMC, Senior Vice President for U.S. Government & International Military Programs, Bell Helicopter
Mr. Patrick Shanahan, Vice President and General Manager, Boeing Rotorcraft Systems
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Mr. Anthony Melita, Deputy Director for Land Warfare & Munitions, Defense Systems, OSD
Mr. Richard Gilpin, Chief of Naval Operations, Office of Aviation Warfare, U.S. Navy
Colonel Robert M. Brown, Office of Chief of Staff, Assistant Secretary of the Army (Acquisition, Logistics, and Technology), U.S. Army
Colonel J. Dixon, Deputy Commandant for Aviation, U.S. Marine Corps
Mr. Reed Kowalczyk, Deputy G-8, Office of Chief of Staff, U.S. Army

EXECUTIVE SUMMARY

THE INDUSTRIAL BACKDROP AND FUTURE WARFIGHTING CHALLENGE

The vertical lift industrial base still is being shaped by government and industry responses to the Nunn-McCurdy cost breaches of 2001 and the unintended consequences of Department-endorsed teaming arrangements that resulted in an interlocked industrial base that restricted Department and industry flexibility. The Department's budget-driven remanufacture strategy in the 1990s produced a series of sole-sourced relationships, leaving few real competitive opportunities among the helicopter prime contractors to force technology refresh cycles. With limited competition, few new platform contracts, and declining government technology investments, industry was left little incentive to invest in independent research.

Over the next several years, this industry will be shaped by the operational experiences and associated refurbishment requirements for helicopters resulting from the Global War on Terrorism. It also will be shaped by changes in warfighting concepts inspired by the new Joint Staff functional capability concepts,[1] as well as by vertical lift requirements associated with major new Marine Corps, Air Force, and system-of-systems programs. This critical watershed affords both the Department and industry a unique opportunity to plan cogently for future vertical lift demand and associated industrial requirements. This report highlights evolving vertical lift requirements and key DoD challenges in order to better shape the future of this industrial base.

RECOMMENDATIONS

We recommend the following measures to ensure innovation of the vertical lift industrial base as we move to the systems-of-systems that undergird the functional concepts of 21st century warfare:

1) Fund the development of concepts that exceed current capabilities. For example, the Department should redouble its focus and interest in heavy lift as a possible family of capabilities provided for FCS and Sea Basing, drawing on as wide an array of suppliers as possible and structured in a series of competitive awards. A joint program office may serve these Department objectives well.

2) Leverage near-term program and maintenance support decisions to enhance innovation in this industrial base by promoting innovation at every opportunity. This involves not repeating the paradigm of sole sourcing follow-on and support contracts to legacy suppliers, as well as resisting the temptation to procure existing platforms where innovative approaches available in the

[1] See Chairman of the Joint Chief of Staff's Joint Capabilities and Integration Development System (JCIDS), CJCSI 3170.01C (June 2003), specifically the functional concepts—Battlespace Awareness, Command and Control, Force Application, Protection, and Focused Logistics.

industrial base could yield enhanced capability—potentially at less cost. Additionally, industrial base impacts should be a consideration in the development of acquisition strategies.

3) Sustain the U.S. lead in tilt-rotor technology which may in turn reinforce and cross-feed heavy lift concepts. Tilt-rotor is a truly revolutionary technology with the potential to change the future of this sector in manned and unmanned applications.

4) Use innovative proposal evaluation criteria to shape the industrial base.

   - The Department continues to recognize the importance of visible, demonstrated, and continuous improvement in process capabilities, system capabilities, and product and supply chain management.
   - Ambitious readiness standards should also be made part of all follow-on, support, and new aircraft acquisition strategies. Warfighters dependent on vertical lift should not be forced to work around readiness standards a fraction of those typical in the fixed-wing community.
   - System-of-systems, functional capabilities and corresponding interfaces/synergies should be emphasized at every opportunity.

As a consequence, DoD competitions should evaluate each offeror's capability to be responsive to these requirements.

The vertical lift industry must move from an emphasis on individual platforms to focus on system-of-systems concepts, consistent with the Joint Staff's functional capability concepts. This report is intended to inform decision-makers within the Department and the vertical lift aircraft industry to better align decisions and program structures with 21st century capability requirements of the U.S. warfighter.

PART I

THE VERTICAL LIFT INDUSTRY SNAPSHOT: 2001–2003

The vertical lift industrial base continues to be shaped by industry responses to the 2001 Nunn-McCurdy cost breaches. Over the next several years, this industry will respond to the operational experiences and associated refurbishment requirements for helicopters resulting from the Global War on Terrorism. In the longer term, it will be shaped by the Joint Staff's new functional warfighting concepts and vertical lift requirements associated with major new system-of-systems programs. The strategic assessment of all of these factors can provide a unique opportunity to cogently plan for future helicopter demand and associated industrial requirements, providing important guidance to domestic and global suppliers intent on producing innovative, high technology, state-of-the-art products for 21st century warfighting.

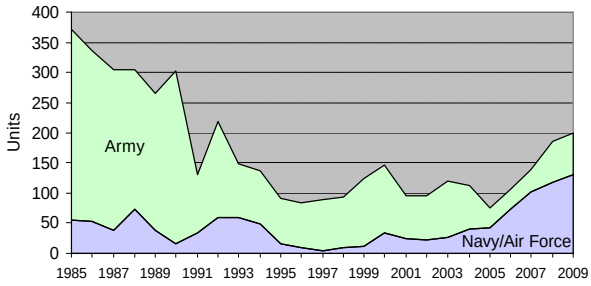
THE VERTICAL LIFT INDUSTRIAL BASE BACKDROP: 1980-2000

The historical backdrop leading to the 2001 Nunn-McCurdy breaches was characterized by plummeting demand, rising unit prices, no industrial consolidation, and lackluster performance of U.S. manufacturers in global helicopter competitions. Each of these factors affecting the vertical lift industrial base will be discussed in the next three sections.

HISTORICAL DEMAND

Annual U.S. military helicopter demand fell from 370 aircraft in 1985 to 90 by 1996. In response to the constrained acquisition budgets in the 1990s, the Military Services opted to remanufacture[2] legacy platforms and focus development budgets on only two new start helicopter programs from the 1980s: the V-22 Osprey and RAH-66 Comanche. With the remanufacture of the AH-64, H-1, H-60, and CH-47 helicopters beginning in 1992, delivered units have ranged from 90 to 120 annually since 1998.

DOD VERTICAL LIFT PROCUREMENT

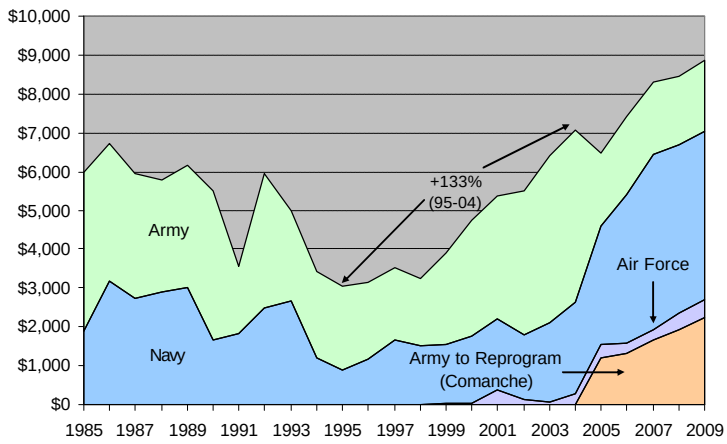


Source: ODUSD(IP) based on FY05 President's Budget and historical data

[2] Remanufacture – The process of using an existing design to manufacture all new components; to disassemble, repair, or replace component parts; and to add new functional capability during the assembly process on a traditional production line. To date, DoD has sole-sourced these activities to the original prime contractors in order to minimize non-recurring cost.

While the purpose of the Department's remanufacture strategy was to constrain budgetary expenditures, this approach proved to be more costly than originally predicted. In part because of enhanced combat capabilities required by the Department and the complexity of integrating these capabilities into legacy platforms, helicopter procurement accounts more than doubled from the 1995 trough of $2.6 billion to the present level of $7.0 billion. Note that data here and throughout this section includes quantities and budget submissions through FY04 for the now cancelled Comanche program. Because the Army has not fully reprogrammed Comanche funds at the time of publishing, Future Years Defense Program (FYDP) numbers for FY05-09 do not reflect these reallocations.

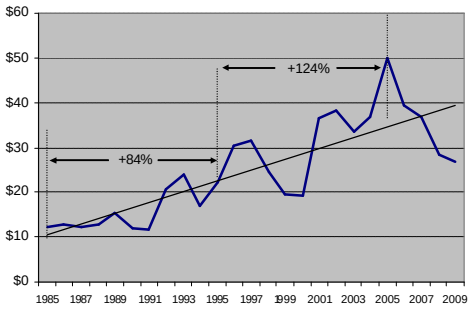
DoD Vertical Lift Program: Procurement & RDT&E (FY04$M)



Sources: ODUSD(IP) based on FY05 President's Budget and historical data

In constant FY04 dollars, average unit cost[3] has more than doubled in the past 10 years and had nearly doubled in the decade prior to that. Such real cost increases resulted from the increase in mission systems technology insertion, the lack of production efficiency, and the absence of production economies of scale. These factors were all exacerbated by the Department's choice to recapitalize by remanufacturing rather than through new development programs. For industry, high unit revenues associated with these sole-source remanufacture programs provide strong cash flow and robust financial returns—but little incentive to fund new designs. In addition, the vertical lift divisions' modest contributions to overall revenues in predominantly non-defense firms provided corporate leadership with little incentive to assign focused attention or resources to these divisions.

Average Unit Cost Increases 1985-2009 (FY04$M)



Sources: ODUSD(IP) based on FY05 President's Budget and historical data

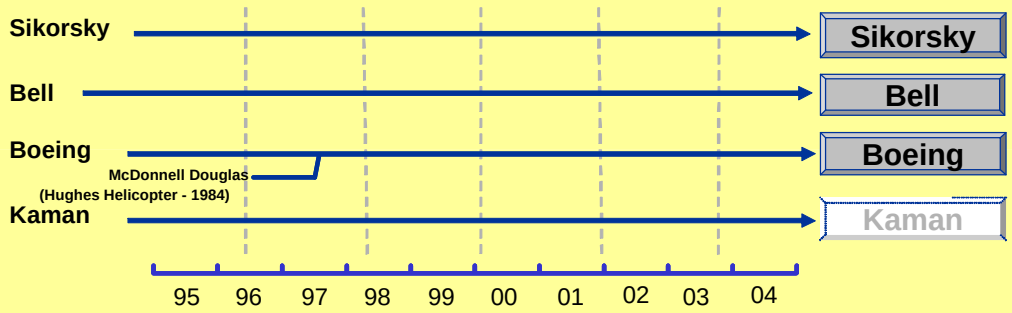
[3] Calculated at the aggregate level as the total RDT&E and Procurement funds for all rotary wing platforms in each year divided by the associated total purchase quantity for that year. Includes: AH-1W, AH-1Z/UH-1Y, AH-64A, AH-64D/Longbow, CH/MH-53, CH-47D, CH-47F (ICH), MH-60R, MH-60S, OH-58D, SH-60B/F, UH-60L, and CV/MV-22.

Further, as the graph opposite indicates, based on current acquisition quantities dramatic reductions in unit cost are programmed by the Department. Thus, cost control and improved production efficiency must continue to be priorities of industry leadership. The Department, recognizing the need for both innovation and cost control, can help industry strike the proper balance by funding the development of concepts that exceed current capabilities while continuing to incentivize cost reduction.

COMPOSITION AND FINANCIAL TRENDS OF THE INDUSTRY

Unlike the fixed-wing aircraft industrial base which consolidated from eight to two primes since 1990, the vertical lift industrial base is essentially the same as it was in the early 1990s. Only one supplier was absorbed: McDonnell Douglas (including the former Hughes Helicopter) in the merger with Boeing in 1997. The composition of the U.S. vertical lift industry in the early 1990s and its limited transformation over the next 14 years is depicted in the following graphic.

PARTICIPANTS IN THE U.S. VERTICAL LIFT INDUSTRY



Note: Kaman is not a current DoD supplier.

Source: Industrial Analysis Center (DCMA)

For these three contractors, margins appear to be buoyed by the preponderance of remanufacture and aftermarket contracts which seem, by inference, to have higher margins than these companies' other defense and industrial business units, as shown in the table opposite. A wide survey by the Defense Contracts Management Agency (DCMA) of contracts issued over the past five years supports this conclusion. Survey data show negotiated profit margins, including award and incentive fee potential in the case of cost plus contracts, in the range of 10-16 percent.

OPERATING MARGIN COMPARISON (CY03)

	Helicopter Business Unit[1]	Other Defense & Industrial Business Units[2]
United Technologies	13.8%	13.4%
Textron	10.0%	5.9%
Boeing	13.2%	8.1%

[1] Flight Systems (United Technologies); Bell (Textron); Aircraft & Weapon Systems (Boeing)

[2] Otis, Carrier, Chubb and Pratt & Whitney (United Technologies); Cessna, Fastening Systems and Industrial (Textron); Network Systems and Support Systems -- Lauch & Orbital Systems withheld due to large one-time loss (Boeing);

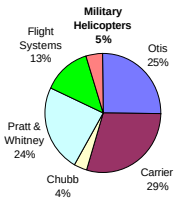
Sources: Company Reports

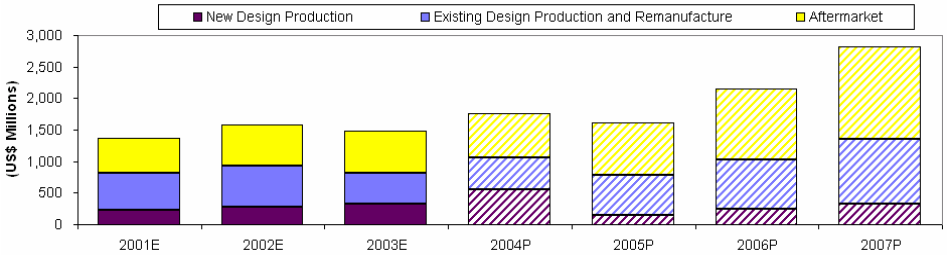
Furthermore, as shown in the chart below, the outlook for the military business base for the three incumbent helicopter manufacturers is stable. Under current planning, Sikorsky and Bell will see substantial revenue gains in the 2006/2007 timeframe, while Boeing's revenues appear to remain stable at relatively high levels.[4] As such, these business segments with substantial captive aftermarket and remanufacturing programs are desirable portfolio operations in these three corporations with other aerospace or multi-industrial holdings.[5]

MILITARY VERTICAL LIFT REVENUE ESTIMATES

United Technologies

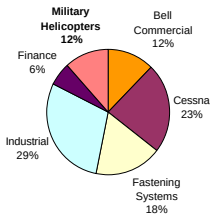
2003 Revenue

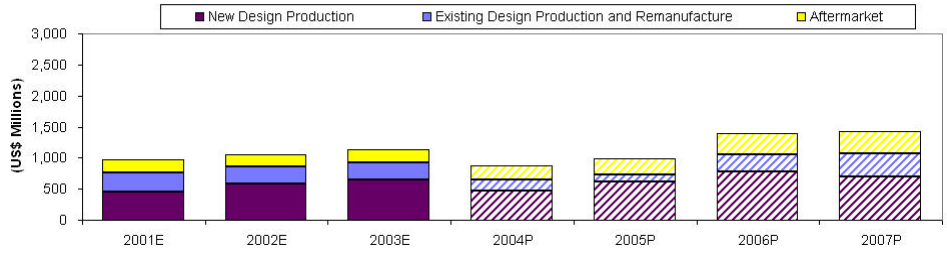




TEXTRON

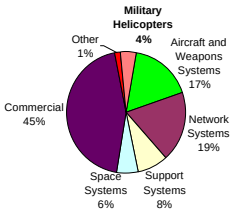
2003 Revenue

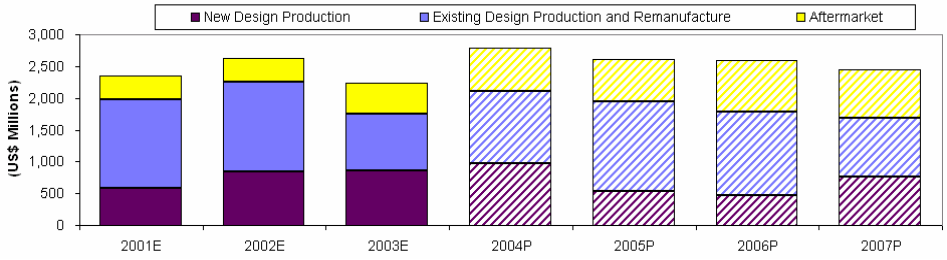




BOEING

2003 Revenue





Note: Helicopter segment results represent military related helicopter sales only

Sources: First Equity Development, Inc. estimates, company and DoD program and budget data, and other public and proprietary information.

[4] Boeing's apparent flat business base for future years is the result of Comanche funding not yet being allocated as this report goes to publication. We expect some of this funding will upgrade AH-64s to a Block III configuration and procure additional CH-47s beyond current plans—exact numbers are yet to be determined.

[5] "Captive" aftermarket and remanufacture describes the often sole-source nature of segment sales.

The relative consistency and profitability of this business base has not encouraged structural changes or major technological breakthroughs among current suppliers in the vertical lift manufacturing business. In fact, new entrants are already challenging the incumbency of these three manufacturers: challenges to this incumbency are coming from global suppliers as they leverage medium lift expertise for unmanned and heavy lift rotorcraft and from systems integrators as systems integration assumes greater importance than platform manufacture. Lockheed Martin, through the acquisition of IBM Systems, became involved in the development of the common cockpit and mission systems equipment for the MH-60R/S as a systems integrator in 1996. Indeed, in the MH-60R, mission systems equipment and the integration of these systems represent more than 45 percent of the flyaway cost. Northrop Grumman has also entered the market as a mission systems integrator for the H-1 Upgrade program and their strong integration and engineering skills were instrumental in capturing a position on the Sikorsky VXX Presidential helicopter team.

Ultimately, the base of defense suppliers will continue to broaden to meet the Department's demand for innovation. The vertical lift sector will be no different, and smaller suppliers with advanced concepts could offer the Department robust options that today's prime contractors may not be motivated to pursue. Moreover, the Department's increased use of unmanned vehicles will continue to lower barriers of entry for innovative small suppliers.

PERFORMANCE IN GLOBAL COMPETITIONS

The record of contract wins of U.S. vertical lift manufacturers in global, civilian and non-DoD helicopter competitions also may reflect the industry's focus on remanufacture at the expense of innovation. While there have admittedly been few U.S. competitions to drive the innovation potential of U.S. vertical lift suppliers, there have been many global competitions for military helicopters that U.S. manufacturers could have used to refresh their products. As the chart on the next page shows, U.S. suppliers have not performed particularly well—the Canadian Government's recent selection of Sikorsky's H-92 as a replacement for their aging fleet of Sea Kings notwithstanding.

A closer look at the 19 helicopter competitions reveals the following picture. In the early competitions, particularly for Attack and Armed Reconnaissance (Netherlands, U.K., Egypt, and Singapore), the U.S. AH-64 Apache typically won partly because the aircraft had been in production for more than 10 years while the Tiger was not yet in production. In addition, the Apache had proven effective in Operation Desert Storm.

France and Germany, both members of the European Union, decided in 1992 to combine resources to develop and promote their domestic helicopter industries by creating Eurocopter from the former French Aerospatiale and German MBB. Their immediate focus was on the creation of a European attack and combat support helicopter, the Tiger, and a medium lift transport, the NH-90, to fulfill NATO and domestic needs. The parent aeronautics agencies of both countries cooperated in joint studies throughout the 1990s and in the incorporation of advanced technologies in both

RECENT INTERNATIONAL HELICOPTER COMPETITIONS (1995-2003)

Year	Program	Quantity	Purchased By	Program Winner	Other Bidders	Notes
1995	Netherlands Attack Helicopter	30	The Netherlands	Boeing AH-64	Eurocopter Tiger, Bell AH-1W	Demonstrated success in first Gulf War, 130% economic offsets to Dutch firms
1995	UK Attack Helicopter	67	United Kingdom	Boeing AH-64	Eurocopter Tiger, Bell AH-1W	Demonstrated success in first Gulf War, Westland builds domestically under license, 100% economic offsets
1997	European Attack and Combat Support Helicopter	427	France & Germany	Eurcopter Tiger	Boeing AH-64, Bell AH-1W	Produced entirely in France and Germany, highly sophisticated
1999	Singapore Attack Helicopter	8	Singapore	Boeing AH-64	Eurocopter Tiger, Bell AH-1W	Major support contracts to Singapore firms, large economic offsets, advanced technology
1999	South Korea Tactical Transport	13	Republic of South Korea	Eurocopter Super Lynx	Information Not Available	Longstanding relationship between Westland and South Korea
2000	Canadian Maritime Helicopter Program (MHP)	15	Canada	AgustaWestland EH101	Boeing CH-47 Chinook, Eurocopter Super Puma, Sikorsky UH60 Maplehawk	Cormorant variant of original selection, large economic offsets and support contracts
2000	Egyptian Attack Helicopter	35	Egypt	Boeing AH-64	Eurocopter Tiger	Aircraft remanufactured to AH-64D specifications
2000	Europeam Medium Lift Transport Helicopter	595	Germany, France, The Netherlands	NH Industries NH-90	Sikorsky S-92	Entirely built in Germany, France & the Netherlands. Highly advanced Technology, all-composite, fly-by-wire, 2nd-generation bearingless main rotors
2001	Nordic Standard Helicopter Program (NHSP)	56	Sweden, Finland, & Norway	NH Industries NH90	Sikorsky S-92 (teamed with Saab), AgustaWestland EH101	Competition rules changed, general agreement on early bias towards European offering, expensive process
2001	Denmark (Broke from NHSP)	14	Denmark	AgustaWestland EH101	Sikorsky S-92 (teamed with Saab), NH Industries NH90	Competition rules changed, general agreement on early bias towards European offering, expensive process
2001	Austrailian Army Project AIR87 Armed Recon Helicopter	22	Austrailia	Eurocopter Tiger	Boeing AH-64D Apache, Bell ARH-1Z Taipan (Cobra), Agusta A129 Scorpion (Mangusta)	First major int'l win (outside Europe) for Tiger, large economic offsets, local production, "good value for money," "excellent balance of capability and affordability"
2001	Japanese Armed Recon Helicopter	60	Japan	Boeing AH-64	Eurocopter Tiger, Bell AH-1W	Fugi Heavy Industries builds domestically under license, destined for Japan Ground Self-Defense Forces
2002	Omani Tactical Transport	16	Oman	Europcopter Super Lynx 300	Information Not Available	Hot climate and high altitude required a powerful engine; historical links to UK facilitated award
2002	Los Angeles County Sheriff	12	USA	Eurocopter AS350B2	Bell 407, MD 600N	Replaces fleet of MD500Es, 520Ns, and 600Ns; evaluation criteria included customer support and performance in varying environments; previously selected by a number of law enforcement groups in CA
2002	United States Coast Guard (Deepwater)	34	USA	Bell/Agusta AB 139	S-92A, EC-155	Rotorcraft manufacturers partnered with industry teams, strength of team bid had strong influence on program award (EC w/ BA, SK w/ SAIC, Bell w/LMT (winner))
2003	Hellenic Army	34	Greece	NH Industries NH 90	Sikorsky H-92	Purchase included an offset agreement with various Hellenic industry groups
2003	Japanese UH/SH-60JX upgrade & minesweeper programs	14	Japan	AgustaWestland EH101	Sikorsky S-92	First non-US selection; based on heavy lobbying and a successful civil aircraft in operation by Tokyo Metro Police
2003	Spanish Armed Reconnaissance Helicopter	30	Spain	Eurocopter Tiger	Boeing AH-64	Large offsets, local production and support, CASA joins EADS
2004	Canadian Anti-Submarine Warfare Helicopter	28	Canada	Sikorsky H-92	AgustaWestland/ Lockheed Martin EH101	After years of delay, the H-92 will replace the fleet of Sikorsky CH-124 Sea Kings, primarily on cost grounds over the more expensive EH101
			U.S. Win		**Non-U.S. Win**	

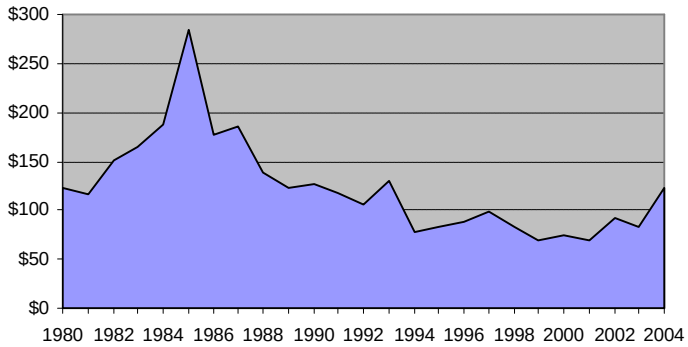
Sources: First Equity Development, Inc. and American Helicopter Society (AHS)

designs. Government order commitments were provided before the beginning of production of both aircraft. Hence, neither the 1997/1999 European Attack and Combat Support Helicopter competition nor the 2000 European Medium Lift Transport competition were truly open to U.S. entries. Similarly, it could be argued that European bias led to the selection of the NH-90 in 2001 for the Nordic Standard Helicopter Program, the Hellenic Army Transport, and the Spanish Armed Reconnaissance Helicopter—both in 2003—although U.S. offerings were carefully considered.

On the other hand, the competition for the Australian Army Armed Reconnaissance Helicopter was an open competition with the AH-64 Apache widely expected to win. Eurocopter won the competition, however, with the highly advanced and less expensive Tiger, now at rate production. Europe's commitment to long term, stable investments in rotorcraft research and development has now paid off and leveled the playing field for international helicopter competitions.

This record is unlike the record of U.S. fixed-wing platforms. When domestic markets are stagnant, companies normally turn to the global marketplace for new or sustaining business. The F-15, F-16, and F/A-18 provide good examples of this. As U.S. procurement of new platforms decreased, McDonnell Douglas, General Dynamics, and then Boeing and Lockheed Martin took their products to the world market with tenacity and have had great success—even in the face of subsidized European fighter aircraft and the requirement for offsets. Part of the reason that these aircraft succeeded in international competitions was that Department fixed-wing research funding and follow-on platform development was unrelenting. The combined effect has been to sustain innovation at the major subsystem level.

TRENDS IN DOD VERTICAL LIFT SCIENCE & TECHNOLOGY (FY04$M)



Sources: AHS and DoD Comptroller

The Department's investment record was different in the vertical lift industrial base. An in-depth assessment shows that the United States poured substantial sums of money into vertical lift research and development from 1960 to 1985. These investments yielded revolutionary products such as the T700 engine powering the Apache and the Blackhawk. Then in 1985, government—and industry—investment in research related to vertical lift platforms began steadily declining. NASA and the FAA have also dramatically reduced spending on vertical lift R&D, lowering overall U.S. investment by nearly 50 percent.[6]

[6] Flater, M.E. Rhett, *Testimony Before the House Armed Services Committee: The Aviation Industrial Base and the Department of Defense Rotorcraft Investment Programs*, Washington, DC, March 4, 2004.

Additionally, innovation has also not been a key requirement in many of the Department's planned acquisitions, relying on the same technology that had been used on prior platforms for decades. And finally, to compound this decline, the Services are spending increasing proportions of their limited research investments on unmanned solutions. For example, the Department's Project Reliance[7] for vertical lift science and technology, plans to shift its research investment to unmanned platforms, at the expense of manned platforms, from 18 percent in 2002 to 74 percent in 2006-2009. Industry, on the other hand, expended limited independent research and development funds on new platforms that were focused on the commercial market. If the Department wants the vertical lift sector to be as innovative as the fixed-wing sector has been and as successful in foreign sales, it will have to increase and sustain manned and unmanned vertical lift investment and use new programs to stimulate innovation.

THE NUNN-MCCURDY WAKE-UP CALL: 2001

2001 proved to be a year of reckoning for DoD helicopter programs. The Department's acquisition strategies of the 1980s and 1990s which encouraged teaming and focused on remanufacture programs sole-sourced to the original equipment manufacturers had resulted in an interlocked helicopter industrial base. Platform-specific strategies and inadequate attention to the industrial base impacts had unintended consequences. With limited competition among helicopter prime contractors and few new platform contracts, industrial relationships were formed to reduce risk and smooth revenue flow absent new program starts. Interlocking contractor teams, spanning across platforms, had long deprived the Department of maneuverability in decision-making. Restructuring in a single program typically had consequences on other programs produced by teammates, often across the Military Services. One consequence was that Department decision-makers were loathe to unleash complex—and costly—chain reactions by proactively managing helicopter programs to cost and schedule goals. Under these circumstances, day-to-day management preempted long term planning for innovation.

Nunn-McCurdy Act

The Nunn-McCurdy Act requires that the respective Service Secretary notify Congress if a program experiences a greater than 15 percent increase to its acquisition or average procurement unit cost. With a greater than 25 percent unit cost increase, before a program can continue, the Secretary of Defense must certify for Congress that:

"(1) such acquisition program is essential to the national security;
(2) there are no alternatives to such acquisition program which will provide equal or greater military capability at less cost;
(3) the new estimates of the program acquisition unit cost or procurement unit cost are reasonable; and
(4) the management structure for the acquisition program is adequate to manage and control program acquisition unit cost or procurement unit cost."

Title 10, § 2433, Chapter 144, Major Defense Acquisition Program—pages 262-263.

[7] In the early 1990's the Department of Defense assigned lead Services for the development of key technology areas; the Army was appointed lead for vertical lift technology while the Air Force was given lead for fixed-wing technology.

The impact of this structure became obvious when four rotorcraft programs—the H-1, CH-47F, V-22, and MH-60R—breached their 15 percent Nunn-McCurdy unit cost limits virtually simultaneously in 2001. In fact, rotorcraft programs accounted for four of the nine programs with cost breaches that year. This placed four of a total of only five Department-wide helicopter acquisition programs in breach status.

The table below details program office and CAIG cost estimates, as well as each program's corresponding percentage cost growth. The H-1 and CH-47F programs required Secretary of Defense certification; the V-22 and MH-60R required Congressional notification. The Department viewed the unit cost breaches of the four major helicopter programs as a manifestation of a systemic problem within the vertical lift industrial base.

THE NUNN-MCCURDY CHALLENGE : 2001

Programs Facing Nunn-McCurdy	Approved APB[1]	Program Cost Estimates		Cost Growth APUC/PAUC[2]	Nunn-McCurdy Status
		PM	CAIG		
H-1	$3,966[3]	$6,234[3]	$6,709[3]	49% / 52%	**Certification Required**
CH-47F	$2,524[4]	$5,321[4]	$5,742[4]	95% / 90%	**Certification Required**
V-22	$27,029[5]	$29,505[5]	N/A	20% / 25%	**Notification Required**
MH-60R	$4,326[6]	$7,156[6]	N/A	17% / 19%	**Notification Required**

[1] APB = Acquisition Program Baseline
[2] APUC = Average Procurement Unit Cost; PAUC = Program Acquisition Unit Cost
[3] Fiscal Year 1996 Base Year $M
[4] Fiscal Year 1997 Base Year $M
[5] Fiscal Year 1986 Base Year $M
[6] Fiscal Year 1993 Base Year $M

Source: PA&E, USD(AT&L)/DS/LW&M, ARA

The V-22 and MH-60R cost increases were attributed in part to requirements—or constructive—changes. Since constructive cost changes are exempted from Nunn-McCurdy threshold limits, once these constructive changes were accounted for, the V-22 and MH-60R programs no longer breached the 25 percent certification threshold. To deal with the H-1 and CH-47F certification requirements, the Services and the CAIG developed new program cost estimates and reconfigured program management structures and incentives. These certification criteria, as shown on the next page, were designed to preclude future cost breaches.

THE NUNN-MCCURDY CERTIFICATION CRITERIA

Nunn-McCurdy Criteria	H-1	CH-47F
1) The program is essential to national security	• Integral element of Marine air-ground task forces • Provides attack, reconnaissance, escort, command and control, utility, and casualty evacuation	• Primary vertical lift asset for Army's maneuver warfare capability • Provides ground forces transport, ammunition supply missions
2) There are no alternatives which will provide equal or greater military capability at less cost	• Attack alternatives: Apache and Comanche – Additional cost and capability in excess of Marine requirements – Program issues • Utility alternative: MH-60S – Operation and support cost difference: $500M – Life cycle cost difference: $1B	• Alternative: CH-53 – Marginal high hot hover capability – Will not meet altitude requirement – Acquisition cost greater than CH-47
3) The new estimates of the program are reasonable	• Program funded to CAIG's cost estimate ($475M increase)	• Program funded to CAIG's cost estimate ($421M increase)
4) The management structure for the program is adequate to manage and control it	• New Integrated Product Team management structure at Navy and Bell designed to enhance system engineering and production management • Bell replaced senior leadership	• Boeing has strong systems engineering and system integration capability/experience • Cost breach due largely to labor/ overhead rate increases, material cost growth, and directed scope changes • New lean assembly line validated during SDD and proven on FMS aircraft

Sources: PA&E, USD(AT&L)/DS/LW&M, ARA

The Department continues to watch these programs closely, monitoring the prime contractors' management, manufacturing, and engineering performance. Cost, schedule, and performance challenges dictated that the Department resolve the Nunn-McCurdy issues methodically, but also as quickly as possible. However, changes in the vertical lift industrial base since 2002 have still largely been limited to improved production efficiencies to meet restructured program cost targets.

THE INDUSTRIAL RESPONSE: 2001-2003

In response to the Nunn-McCurdy cost breaches, the vertical lift prime contractors have taken steps to improve production efficiency. They are upgrading their management information systems (MIS) to be responsive to the Department's desire to institute Earned Value Management (EVM). Until the Nunn-McCurdy crisis, this industry outsourced little component fabrication—a practice which limited competition within the second and third tier supply chain and resulted in an extremely vertically-integrated sector. Each company managed day-to-day functional operations as independent entities, not as a seamless, coordinated enterprise. This business structure made it particularly difficult for industry managers to have sufficient insight into their operations and control costs effectively as production rates declined.

To understand each company's manufacturing processes and efficiency, the Department conducted a series of plant visits in 2003 and 2004. It assessed each facility's tooling and equipment; staffing; management tools; planning and control processes; and supplier management systems. The assessment found that since 2001, each company has made strides to update their business and management practices as they move toward a lean manufacturing paradigm and away from the vertically-integrated structure of the past. But much work remains.

SIKORSKY AIRCRAFT

- Moving toward lean manufacturing implementation of basic concepts
- Experienced CEO at helm
- E-commerce suppliers initiative
- Implementing electronic management tools

- Limited impact in final assembly and component production due to legacy tooling
- Commitment to new technologies questionable
- After-market business focus

Sikorsky Aircraft has a history of being a leader in this industry. It invested its own money in the development of the H-92, the first new U.S. helicopter in more than a decade and a Collier Trophy winner in 2003. For all of its past innovation and success in vertical lift technology, however, Sikorsky has been slow to embrace lean manufacturing. Over the last two years it has started to move in this direction, improving final assembly flow times for some components by as much as 30 percent. Such improvements should allow Sikorsky to implement a "pull" parts flow system, thereby substantially improving production efficiencies, reducing shop inventories and the need to warehouse inventories.

In support of their aftermarket business, Sikorsky also maintains significant vertical integration and 30 year old complex tooling concepts. EVM is difficult due primarily to its antiquated MIS infrastructure. New leadership has made updating Sikorsky's MIS systems a top priority and should have it on line by December 2005.

"We made a decision in 2003 to apply Earned Value Management to all programs at Sikorsky, whether the customer required it or not. Furthermore, we recognize that our legacy IT systems are not as conductive as desired for quick and effective EVMS reporting. Accordingly, Sikorsky is investing its own money in implementing an Enterprise-wide Resource Planning (ERP) system, which by December 2005 will have Sikorsky running SAP as the backbone of our company operations. This will assure rapid, accurate data is available for the requisite Earned Value analysis."

- Mr. Stephen Finger
CEO, Sikorsky Aircraft

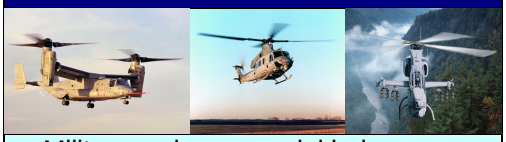
Indeed, Sikorsky's after-market business focus concerns the Department because of the potential adverse impact it could have on innovation of new concept platforms and by acting as a disincentive to improve component part reliability. If the after-market business can be seamlessly and synergistically incorporated into the production business, it could be a positive factor, providing at least incremental innovation. However, in the absence of new development programs, such work could dominate the company's long-term business strategy. If this were to occur, suppliers like Sikorsky could become oversized

"After-market support is focus growth area for Sikorsky. It is partnering with customers to provide affordable new equipment and logistics solutions."

- Mr. Stephen Finger
CEO, Sikorsky Aircraft

parts and assembly factories, missing opportunities to compete effectively for challenges demanding large scale integration of innovative new concepts. Mr. Stephen Finger, Sikorsky's new CEO, has a strong background in the implementation of lean manufacturing which should be beneficial as Sikorsky remakes itself to fit the 21st century business model.

BELL HELICOPTER



- Military and commercial balance
- Institutionalizing lean manufacturing
- Improving productivity
- Faltering business management tool implementation

- Management process transformation necessary
- Management turnover issues—unproven as a team
- Parts production and supply chain management still not synchronized to final assembly needs
- After-market business focus

Bell is also working to improve the overall operational performance of its business. It is institutionalizing lean manufacturing; however, its effort to put in place a "pull" production line for V-22 has not fully matured. At the subcomponent level, Bell is harmonizing component part production with its final assembly process. Bell is using "six sigma" analyses to improve quality and productivity by improving process flow. The shop floor space gained will make room for increased V-22 production and initial low rate H-1 Upgrade production. These programs' ramp will provide further incentives to improve production efficiency through the use of lean manufacturing.

To facilitate this transformation, Bell has a four year plan to rebuild the MIS infrastructure. Bell is investing over $80 million in company money to implement a new Advanced Enterprise Management system (EVM) and over $20 million in company money on a new EVM system. This will greatly improve Bell's ability to manage by EVM, but the Department would like to see the timeline for implementation accelerated to more rapidly achieve better internal and external supply chain management. That said, Bell's recent failure to achieve Navy EVM system certification is of grave concern to the Department.

In parallel, Bell is developing many vertical lift innovations. These range from the commercial application of tilt rotor technology on the Bell-Agusta 609 to the component technologies such as the Propulsive Anti Torque System (PATS) in test for Unmanned Combat Armed Rotorcraft (UCAR). Bell has also wind tunnel tested revolutionary technology such as Stop Fold Tilt Rotor to allow operation at speeds greater than 400 knots and Quad Tilt Rotor heavy lift capabilities in excess of 20 tons. Bell has also spent it own funds to build and demonstrate Tilt Rotor technology on the Eagle Eye UAV.

By bringing in executives with broad general management experience such as the new CEO, Mr. Mike Redenbaugh, Bell is focused on transformation and culture change to continue to bring innovation to vertical lift aircraft while strengthening overall operational performance. Bell is taking advantage of the talent pool developed by other companies in the aerospace industry. If management turnover is stabilized and as senior leadership learns to work together, the company should realize even greater

improvement in operational efficiency. The Department remains concerned that Bell, like Sikorsky, is maintaining an excessive focus on after-market business.

BOEING

Philadelphia
- Institutionalizing lean manufacturing
- Excellent final assembly tooling
- Improved business management tools in place

- Implementation of lean on CH-47 line slower than expected
- Lean final assembly process not proven

Mesa
- Institutionalized lean manufacturing
- Integrated supply chain
- Electronic EVMS on shop floor
- Active R&D projects

- Limited production (AH-64D)

Boeing, on the other hand, has aggressively embraced lean manufacturing. Using its Mesa, Arizona facility, Boeing experimented with lean manufacturing and was able to show substantial cost improvements on the AH-64D production line. Boeing learned through its Mesa operations that outsourcing and leveraging competitive pressures could help to control both cost and quality. This freed labor talent for core competency operations: manufacturing aircraft. Boeing has outsourced most component production, with the exception of wiring harnesses and a few low cost components. It has demonstrated the importance of doing active technology development aligned to its design and production core competencies, this accomplished in collaborative efforts with its Phantom Works.

Over the past two years, Boeing's Philadelphia, Pennsylvania operation has aggressively put in place the same business model used at Mesa. As production of the V-22 and the CH-47F/G increases, Boeing should be able to fully deploy the same lean manufacturing "pull" system proven in Mesa. A lean V-22 production line is up and running. Impressively, the manufacturing engineers have been able to keep final assembly costs down while also minimizing costs associated with additional future production capacity. The CH-47F/G line is implementing lean slowly, but still successfully accommodates two different aircraft configurations on the same line. Based on the success Mesa has had with multiple configurations on lean production lines, there is no reason the CH-47F/G line should not succeed.

"There are few industries that remanufacture product that is thirty years old—restoration of historic homes and plastic surgery are examples that come to mind. The system inherently limits our ability to offer new and more affordable product."

- Mr. Patrick Shanahan VP & GM, Boeing

Since the Nunn-McCurdy breaches in 2001, the Department has carefully monitored not only the helicopter companies for progress in management practices, but also each individual helicopter program for signs of cost escalation and other performance issues. These helicopter programs are progressing, but still face technical challenges. The table on the following page summarizes the steps taken by the Department in each program since 2001 to control cost.

KEY PROGRAM DEVELOPMENTS: 2001-2003

H-1 (Certification Required)

2001	2003
▪ Restructured with increased emphasis on cost controls ▪ Modified contract and exit criteria to include demonstration of cost and schedule performance targets—LRIP to start in 2005 ▪ Adopted "buy-to-budget" approach ▪ Navy developed plan to define realistic and aggressive cost reduction targets, fund quality enhancement program, and facilitate competition	▪ Significant flight test success ▪ EMD schedule remains area of focus ▪ Bell selected Amarillo, Texas, as production site ▪ LRIP scheduled to start spring 2005

CH-47F (Certification Required)

2001	2003
▪ Restructured to fund procurement phase at Government's estimate ▪ Reduced annual quantities with stretched program ▪ Joint contractor and PM emphasized cost monitoring ▪ Contractor modified cost models to include "over-and-above" costs	▪ Army's only heavy lift helicopter ▪ Best heavy lift in high hot environment as shown in Afghanistan in OEF ▪ LRIP phase on schedule and within cost ▪ Significant advances in development and refinement of production processes to reduce cost ▪ Will be challenged with switching from CH-47F to MH-47G for Special Operations Forces

V-22 (Notification Required)

2001	2003
▪ Restructured to resolve technical design problems ▪ Authorized to proceed with comprehensive and rigorous event-driven flight test program ▪ Kept LRIP quantities at minimum sustaining rate (11/year) pending review of technical progress in flight test	▪ May 2003—technical performance validated in flight test ▪ August 2003—annual production quantities adjusted for more gradual ramp-up rate o Cost savings from adjustment reinvested in interoperability and capability improvements o Multi-year procurement directed

MH-60R (Notification Required)

2001	2003
▪ Attributed much of cost growth to "over-and above" costs associated with remanufacturing old airframes ▪ Restructured as a "buy new" procurement beginning with LRIP Lot II	▪ Initially plagued by avionics performance and systems integration problems ▪ Poorly defined test parameters led to initial questioning of performance of radar, external stores management, and acoustics subsystems—testing requirements have been clarified ▪ Shifting from remanufacturing to new production has helped to control program production cost

Sources: ODUSD(IP), Boeing, Bell, and Sikorsky

CONTINUING PRODUCTION OPPORTUNITIES

The industrial base on which the Department and 21st century warfighters will draw for manned—and increasingly, unmanned—vertical lift requirements has had little incentive to innovate over the past 20 years and is only now beginning to modernize as a result of remedial actions taken in conjunction with Nunn-McCurdy certifications in 2001. Furthermore, significant repair required by ongoing operations and the robust backlog of legacy platforms reinforce the inertia impeding innovation and invention in this industry.

Near-term, significant activity will remain in the remanufacturing and aftermarket repair and support business. The Army is moving forward with a $15.1 billion sole source contract to Sikorsky to remanufacture more than 1,217 Blackhawks—upgrading them to the UH-60M variant—and also to build about 200 new aircraft. If the Marine Corps goes forward with the CH-53X program, Sikorsky will be awarded another large sole-source contract to build 154 upgraded CH-53s. Bell will have residual UH-1/AH-1 work with an estimated contract value of $6.7B. Boeing will remanufacture 370 CH-47s over a 12 year period with a contract value of $7.0B. With the cancellation of the Comanche program, Boeing now has an opportunity to be awarded a sole-source contract with the Army to upgrade 284 AH-64Ds to a Block III configuration. This would provide backlog for their Mesa facility for the next seven years.

SOLE-SOURCE REMANUFACTURE OPPORTUNITIES

Company	Original Platform	Remanufacture Opportunities	
		Platform (#)	Program Value ($ billion)
Sikorsky	UH-60A (1978)	UH-60M (1,217), UH-60L/M (200)	$15.1
	CH-53E (1980)	CH-53X (154 potential)	TBD
Bell	UH-1 (1960), AH-1J (late 1960s)	UH-1Y (100), AH-1Z (180)	$6.7
Boeing	CH-47A	CH-47F/G (370)	$7.0
	AH-64A	AH-64D Block III (284)	TBD

Sources: PA&E, USD(AT&L)/DS and ARA

The Global War on Terrorism will also affect the near-term revenues of the three primes and their suppliers. As more than 1,000 helicopters rotate out of Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF), they will have to undergo unscheduled repairs. This resetting of the force requires industry to supply parts to the Services and logistics centers, resulting in an additional $1.4 billion being pumped into this sector. The helicopter companies have already started to expand their parts production to meet this demand. The manufacture of these parts will improve near-term revenues, but could exert pressure on new and remanufacturing production—and does little to improve innovation.

In summary, today's pressing operational needs and the Department's failure to fund new technology has discouraged innovation. Industry has—understandably—focused on near-term customer needs from the remanufacture of legacy platforms and aftermarket support. The Department's decisions to pursue off-the-shelf solutions for limited new competitive opportunities will only reinforce this focus—if perpetuated. Going forward, the Department's move toward a functional capabilities warfighting construct and new vertical lift requirements in major system-of-systems programs will change the vertical lift force mix and challenge the associated industrial base—and the Department—to contribute new capabilities required for future warfighting.

PART II

THE VERTICAL LIFT INDUSTRY OUTLOOK: 2004–2014

The Department now views the defense enterprise through a different lens: one organized around functional capabilities. Department programs are currently being structured to reflect this functional concept and embody the system-of-systems philosophy that undergirds it. The use of helicopters in current operations has highlighted their utility, as well as their limitations. Going forward, new demands will be placed on vertical lift assets associated with the new functional capabilities required. Industry must understand that evolving transformational capabilities, such as unmanned sensor platforms and armed unmanned platforms, as well as capabilities resident in other platforms and sensors, will provide a robust set of options for executing the functions served solely by helicopters today. The Department's emphasis will shift from mission-focused platforms to systems enabling capabilities.

THE NEW FUNCTIONAL CONSTRUCT

The graphic on the following page illustrates the Joint Staff's functional concepts mostly influenced by materiel solutions: Battlespace Awareness, Command and Control, Force Application, Protection, and Focused Logistics.[8] These concepts, along with major systems-of-systems and operating concepts such as Future Combat Systems and Sea Power 21 are becoming central themes for Department decision-making.

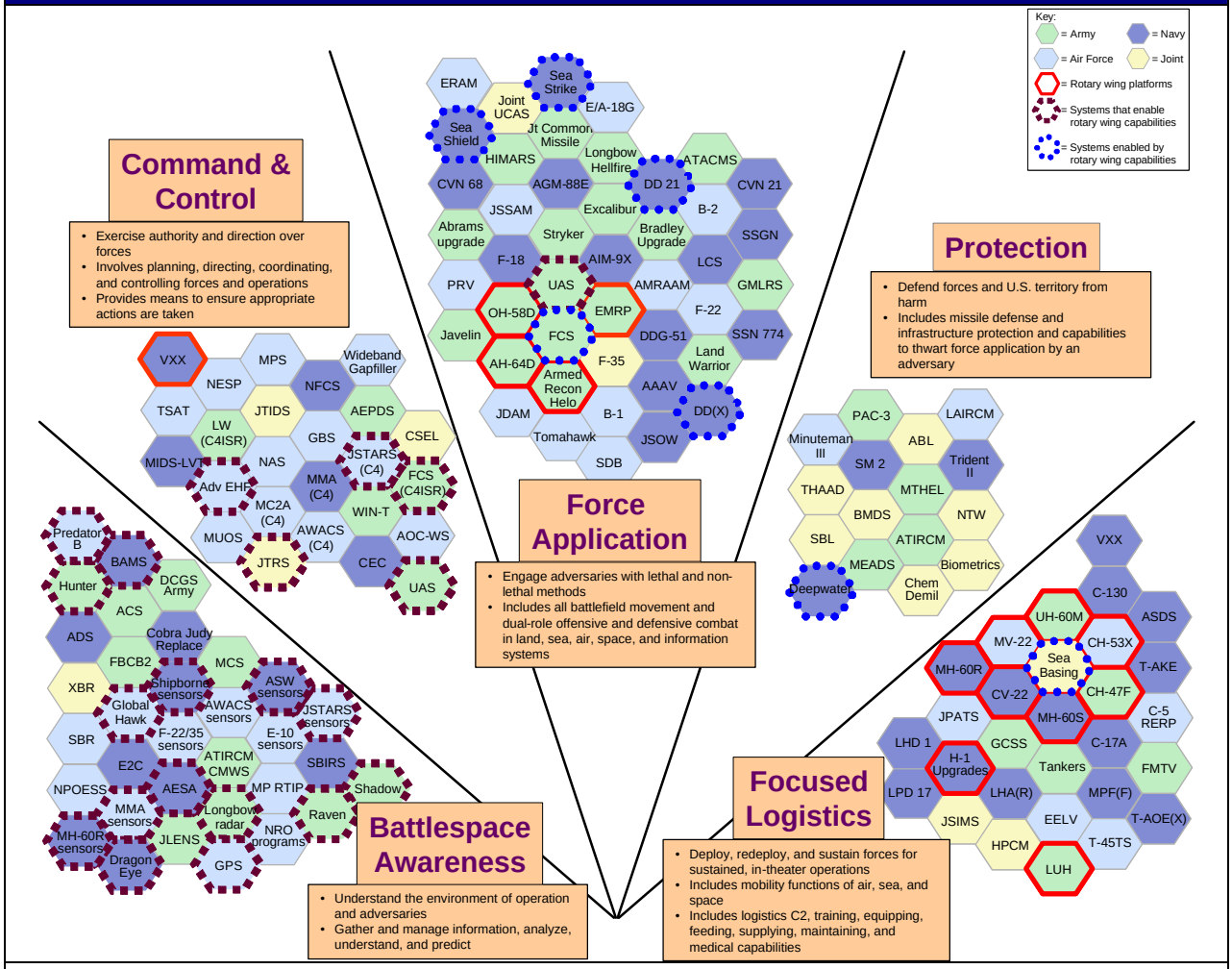
While these concepts are still evolving, the Department is beginning to align legacy programs, research and development initiatives, as well as new programs with functional concepts. Over time, budgetary and acquisition process decisions will be made based on this new paradigm. The graphic illustrates the initial alignment of legacy and future systems-of-systems programs to functional concepts. Vertical lift assets and the associated systems-of-systems they support have been highlighted for emphasis. Clustering indicates platforms that are related or have co-enabling relationships. Not all of the warfighter capabilities supplied by a program fall into a single sector. Many programs can and do support capabilities in multiple functional concepts. The following discussion highlights this interaction across the new functional capabilities.

For example, as part of Force Application, the future Armed Reconnaissance Helicopter can be expected to achieve its full functional capability based upon Command and Control assets such as the Joint Tactical Radio System (JTRS) and the Joint Surveillance and Target Attack Radar System (JSTARS) for communications and enemy positioning. At the same time, it will contribute to and employ Battlespace Awareness capabilities like the Hunter and Shadow unmanned aerial vehicles (UAVs), JSTARS sensors, and the Global Positioning System (GPS) to identify and track

[8] The Joint Staff is developing a sixth functional capability: Net Centric Operations, at the writing of this report.

potential targets. The full potential of the Armed Reconnaissance Helicopter will be achieved when it uses and contributes to all the functional capabilities that will enable it to rapidly find, identify, track, target, and if necessary, engage the opposing force—while providing other sensors and platforms the benefits of having access to its sensor data stream and communication links.

VERTICAL LIFT PLATFORM CAPABILITIES WITHIN THE NEW FUNCTIONAL CONCEPTS[9]



Source: ODUSD(IP)

This capabilities-based construct is fundamentally different from looking at programs or platforms. Embodied in this thinking is the decomposition of platforms into their enabling capabilities and indifference as to how a capability is achieved. For industry to

[9] This notional chart originated from the Defense Acquisition Executive System's (DAES) "binning" of current Major Defense Acquisition Programs (MDAPs) dated January 2004—the binning process continues to evolve. Please note that while the AH-1 does not appear (due to the fact that it no longer has DAES reporting requirements), the H-1 Upgrades appear as Focused Logistics resources. Further, the Personnel Recovery Vehicle does not appear because it is not yet an official MDAP.

be responsive to this new paradigm, it must know and understand the interaction between functional capabilities and the new operating concepts.

> *"I think history will view the Army's decision on Comanche as one of the epic decisions in favor of the new concept of joint operations. The Army was willing to cede its mission area of deep penetration, stealthy strike in recognition that other capabilities in the Department's portfolio could do at least as good a job of preparing the battlefield for ground forces—and without the risks of low altitude and slow speed that Comanche would represent."*
>
> - *Mr. Kenneth Krieg, Director, Program Analysis & Evaluation, Department of Defense*
> *April 29 , 2004*

For 21st century warfighting, it is most likely that vertical lift solutions will make significant unmanned contributions to Battlespace Awareness; unmanned and manned contributions to Force Application; substantial manned, heavy lift contributions to Focused Logistics for troop transport and search and rescue and unmanned contributions for resupply requirements. Going forward, the challenge for the helicopter industrial base will be to change and innovate as required to provide these functional capabilities required by 21st century warfighters.

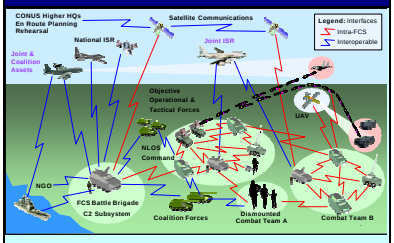
MAJOR NEW SYSTEM-OF-SYSTEMS PROGRAMS: IMPACT ON VERTICAL LIFT DEMAND

This functional capabilities thinking underlies major new system-of-systems programs such as the Army's FCS, the Navy's Sea Power 21 concept, and the Coast Guard's Deepwater program. These programs and concepts will determine long-term demand for vertical lift aircraft, as will Air Force rotorcraft requirements and those for the Marine Corps Expeditionary Strike capability.

FUTURE COMBAT SYSTEM (FCS) IMPACT

FCS is a Force Application system-of-systems operational concept which will use a broad spectrum of sensors and associated platforms networked to allow the future land-based warfighter to track and target the enemy at safer standoff distances. The network-enabled battlefield will potentially be orders of magnitude larger than current operational standards due to multiple, simultaneous operations spanning larger maneuver space than the traditional linear battlefield. This new environment will put demands on operational ranges, speed, sensors, and communications.

FCS CONCEPT



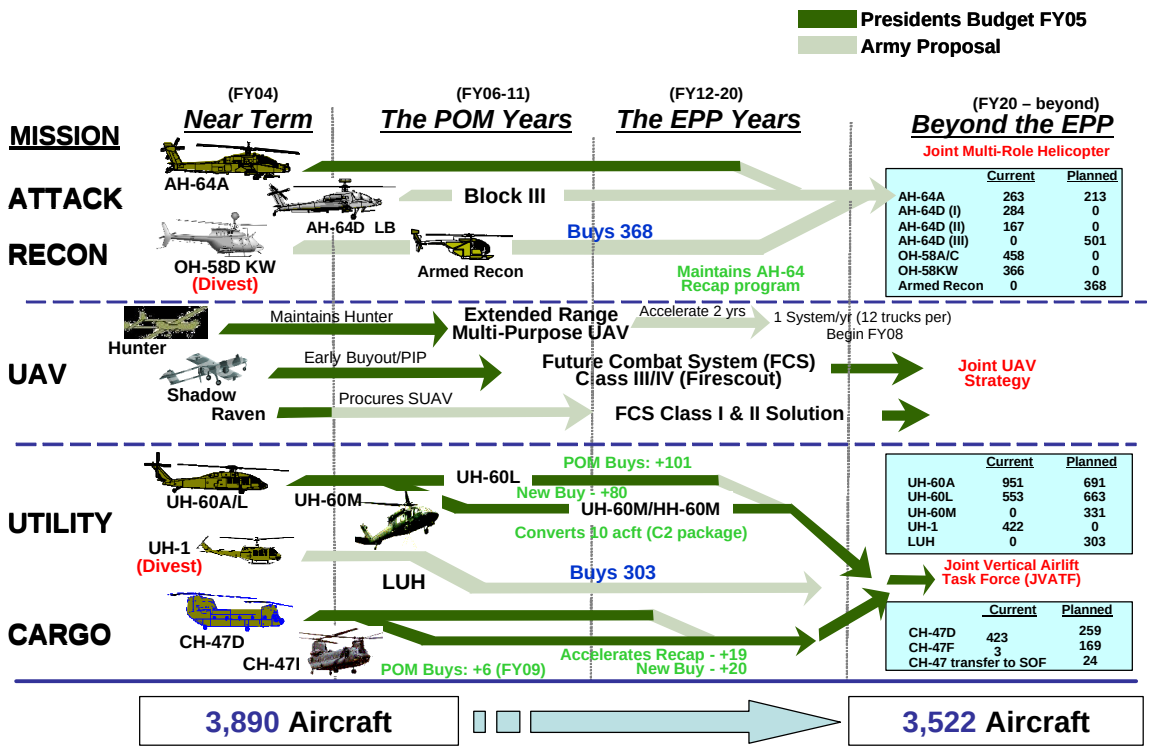
- Networked system-of-systems.
- UAVs for recon and attack roles.
- Manned rotary winged aircraft will function as consumers of net data and nodes within the net.
- Full spectrum integration of data is imperative and will elevate the role of mission equipment and reduce platform importance.

Assets like the Extended-Range Mission Payload (ERMP) rotorcraft UAV, and new Armed Reconnaissance Helicopters will provide critical functional capabilities for FCS. As their sensors scan the battlefield, they will stream real-time data to the FCS command center as well as to overhead assets like the F-35 Joint Strike Fighter or UH-60Ms. The combined capabilities will allow the battlefield commander to apply the best

solution for any given situation. Such operations can only be achieved through a network-centric construct, requiring future vertical lift assets to have unprecedented sensor and communication capabilities.

The chart below outlines the Army's strategy to move toward a force structure that calls for 368 fewer, more-capable manned helicopters than existed in the legacy force structure. Although force structure will be shrinking, recapitalization plans do call for acquisition of new production aircraft, providing new opportunities for current suppliers or new entrants. There will also be an increased use of unmanned aircraft. These unmanned assets will play a major role initially in Battlespace Awareness, but will be followed by weaponized concepts like the ERMP rotorcraft UAVs for Force Application. Industry will be redirected to provide innovative solutions to FCS demands—and to the increased functional capability that future vertical lift aircraft will need to have.

FCS: THE IMPACT ON ARMY AVIATION MODERNIZATION PLAN

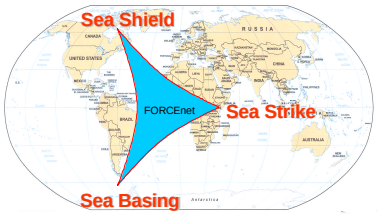


Source: Department of the Army

SEA POWER 21 IMPACT

A similar idea will be implemented at sea. Under Sea Power 21, the Navy plans to implement Sea Shield, like FCS, another Force Application system-of-systems concept. It is structured to defeat anti-access and area-denial attempts, regardless of whether the threats come from enemy surface combatants, submarines, mines, aircraft, or missiles. Highly capable vertical lift aircraft will extend and dominate the battlespace. They will be based at sea and be augmented by numerous manned and unmanned platforms and maritime support aircraft. Again, this calls for maritime vertical lift aircraft of the future to operate as a system-of-systems asset. Range, endurance, and networked sensor suites will be critical if such aircraft are to play an effective role.

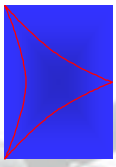
SEA POWER 21 CONCEPT



- A three-component system-of-systems concept: Sea Shield, Sea Strike, and Sea Basing.
- Will reduce emphasis on platform-centric operations in favor of net-centric operations.
- The goal is to enable precise, agile maneuver warfare able to sustain access and decisively influence events ashore and at sea.

SEA SHIELD: THE IMPACT ON NAVY VERTICAL LIFT AIRCRAFT

Force Structure 2004	*Sea Power 21 ~ 2015*
Missions ASW, NSW, SAR/CSAR, ASUW, VERTREP/VOD	**Missions** ASW, NSW, SAR/CSAR, ASUW, VERTREP/VOD, Organic AMCM
CVW Squadrons - 10 CV Helicopter (SH-60F/HH-60H) - 10 S-3B Squadrons Expeditionary Squadrons - 10 LAMPS (SH-60B) Squadrons - 6 Combat Logistics Support - 2 Dedicated AMCM/Vertical Onboard Delivery Squadrons	Sea Shield Expeditionary/ESG Squadrons - 5 MH-60R - 6 MH-60S - 2 MH-53E CSG Squadrons - 10 MH-60R - 10 MH-60S Sea Basing
Primary Mission Aircraft Authorization (PMAA) - SH-60B—124 (6 Reserve) - SH-60F—46 (6 Reserve) - HH-60H—36 (16 Reserve) - MH-53E—29 (8 Reserve) - S-3B—80 - CH-46D/UH-3H/MH-60S—89 (8 Reserve)	Primary Mission Aircraft Authorization (PMAA) - MH-60R—172 (10 Reserve) - MH-60S—158 (16 Reserve) - MH-53E—29 (8 Reserve)
8 Type Model Series **404 Aircraft**	**3 Type Model Series** **359 Aircraft**



Source: Department of the Navy

Sea Power 21 is a three-component system-of-systems concept consisting of Sea Shield, Sea Strike, and Sea Basing. Sea Basing will minimize constraints that host nations can place on overseas land bases by sustaining forward-deployed forces from the sea. Joint forces will thus be able to accelerate deployment and employment times,

enhance sea-borne positioning of joint forces, provide offensive and defensive power projection, and integrate sea-based joint logistics, command and control. Future vertical lift assets of all types will have to seamlessly flow into the command and control structure of this forward operating base at sea. These joint force assets will have to be maritime capable, fully network-centric, and may even demand longer operating ranges. As this concept matures, it will likely create the demand for additional vertical lift assets, the numbers and composition of which can not be accurately forecast at this time.

Sea Shield will integrate information superiority, total force networking, and an agile and flexible sea-based force in an innovative approach to 21st century Navy warfighting. The Navy has started this new concept of operations by transitioning from eight type model series of rotary-winged aircraft to three as depicted in the chart on the previous page. The three aircraft will be MH-60R, MH-60S, and the MH-53E. These Sea Shield aircraft, along with future unmanned assets, will provide a protective cover for Navy/Marine Corps expeditionary and strike groups, as well as future sea basing concepts. As unmanned technology matures and operational confidence grows, one could expect to see a growing reliance on UAV technology and potentially a shift away from manned assets for weapons delivery, as evident by the arming of Predator. The use of these unmanned systems will have the additional benefit of reducing the number of flight hours for the MH-60R, leading to less maintenance and longer life per aircraft. For the time being, manned aircraft have the primary role in weapons delivery because today's manned aircraft carry more weapons than today's UAVs.

With regard to Marine Corps vertical lift requirements in support of expeditionary strike, advanced tilt-rotor technology aircraft, such as the MV-22 Osprey, will greatly enhance the ability to deliver troops, equipment, and supplies from the sea to shore. New vehicle concepts, such as canard rotor/wing, may further revolutionize and transform this capability.

EXPEDITIONARY STRIKE VERTICAL LIFT DEMAND

Aircraft Type	Current Aircraft (#)	Future (#)
CH-46E/ MV-22	218/0	49/205
UH-1N/Y	82/0	39/43
AH-1W/Z	164/0	72/92
Total Manned	464 →	500

Source: U.S. Marine Corps

The chart opposite summarizes the Marine Corps' future force structure changes.[10] By 2014, the 205 MV-22s will form the backbone of the Expeditionary Strike Group's capability, complementing the remanufacture of 43 UH-1Y and 92 AH-1Z assets. The MV-22's high-speed, long range, and maneuverability requirements demonstrate that advanced heavy lift tilt-rotor concepts will need to be more agile, with higher speed than platforms presently fielded.

By reducing the number of type/model/series and adding unmanned capabilities to Sea Shield, the Navy will initially reduce 45 aircraft from its requirements by 2015. This will be nearly offset by the addition of 36 aircraft for Marine Expeditionary Strike vertical lift requirements.

[10] The CH-53X will begin replacing the CH-53E towards the end of this period.

DEEPWATER IMPACT

While not a DoD program, Deepwater is being included in this study as a system-of-systems concept impacting vertical lift demand through 2014. When complete in 2022, the interoperable Integrated Deepwater System (IDS) will include a combination of new and upgraded vertical lift assets; both cutter-based and land-based unmanned air vehicles (UAVs); three classes of new cutters and their associated small boats; and a new fixed-wing manned aircraft fleet. All of these highly capable assets will be linked with networked command and control and battlespace awareness systems, and supported by an integrated logistics regime. While net manned demand increase will be modest, the Coast Guard will replace two-thirds of the existing fleet and add an unmanned platform. This represents substantial opportunities for industry.

DEEPWATER VERTICAL LIFT DEMAND

Aircraft Type	Current Aircraft (#)	Future (#)
HH-65A	96	0
Multi-Mission Cutter Helicopter (MCH)	0	96
HH-60J	42	34
Vertical Recovery System	0	10
VUAVs	0	38
Total		
Manned	138 →	140
Unmanned	0 →	38

Source: U.S. Coast Guard

AIR FORCE VERTICAL LIFT DEMAND IMPACT

Distinct from the Army's and Navy's system-of-systems concepts that affect vertical lift demand, the Air Force role in vertical lift is as the provider of choice of personnel recovery assets. Paradoxically, its near-term requirements represent the best opportunities to structure new, innovative, vertical lift programs. While early indications are that schedule may again dictate modifications to an existing aircraft, industrial base concerns compel serious consideration of a new platform design.

Most importantly, the Personnel Recovery Vehicle (PRV) program intends to replace 104 HH-60s with about 132 new aircraft. This decision is due in the 2005 timeframe. Based on studies

AIR FORCE VERTICAL LIFT DEMAND: KEY DEVELOPMENTS

Mission	Current Aircraft	Replacement	Change
PRV	HH-60	PRV	+ 28
Air Force Space Command	UH-1N	TBD	TBD
VIP Aircraft	UH-1N	TBD	+ 7
AMC Support Aircraft	UH-1N	TBD	TBD
Total		→	+ 35

Source: Department of the Air Force (Air Force Materiel Command)

indicating that one common vertical lift platform is most cost effective, the Air Force intends to address other future helicopter replacements as part of this one program. This requirement would add about 100 more helicopters for Space Command and Support, air base support, and executive lift missions. The graphic on the previous page summarizes the four different mission areas to be covered by this acquisition, indicating a net known increase of 35 platforms—but potentially approaching 150 aircraft.

VERTICAL LIFT DEMAND SUMMARY 2004-2014

As shown below, the major new system-of-systems programs, along with Marine and Air Force requirements foreshadow a different demand outlook for vertical lift aircraft with fewer manned assets leveraging UAV technology as we move toward 2014 and beyond.

VERTICAL LIFT DEMAND SUMMARY

System-of-Systems Concepts	Legacy Platforms	# of Helicopters	Future Platforms	# of Helicopters	Change
FCS	AH-64A, AH-64D, OH-58A, UH-60A/L, UH-1, CH-47D	3,890	AH-64D, OH-58A, UH-60M, CH-47F/G , Armed Recon + UAVs	3,522	- 368
Sea Shield	SH-60B/F, CH-46D, UH-3H, H-1N, H-60H, MH-53E	404	MH-60R/S, MH-53E + UAVs	359	- 45
Marine Corps	CH-46E, UH-1N, AH-1W	464	MV-22, UH-1Y, AH-1Z	500	+ 36
Deepwater	HH-65A, HH-60J	138	HH-60J, MCH, VRS + 69 VUAVs	140	+ 2
Air Force	H-60G, H-1N	197	TBD	232	+ 35
Summary			→		- 340

Sources: ODUSD(IP), Departments of the Army, Navy, and Air Force

While overall vertical lift force structure will decline by over 300 from 2004-2014, remanufacture programs discussed in Part II will sustain the legacy force and new production units will add substantial 21st century capabilities. The procurement of legacy production and remanufactured aircraft shows a commitment to sustain and modernize the current force. In addition, while difficult to estimate, we could envision hundreds of unmanned assets ranging from pocket-sized UAVs supporting FCS to transport-sized unmanned cargo aircraft supporting Sea Basing by the third decade of this century.

Although a large number of vertical lift aircraft will be procured, only the three near-term programs offer opportunities for clean-sheet solutions: the Air Force PRV requirement in 2005, followed by the Army Armed Reconnaissance and Light Utility helicopter

requirements. Later, heavy lift requirements for FCS and Sea Basing could induce new designs. Therefore, these potential new start opportunities represent critical near-term innovation milestones which we fear the Services may pass by in their preference for off-the-shelf or other simple solutions.

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PART III

RECOMMENDATIONS

The rapid growth of innovative technology and its application to transformational warfare have the potential to substantially expand the role of vertical lift aircraft in modern warfare. The Department must position itself to focus the vertical lift industrial base on innovation and the most challenging problems of 21st century warfare. It must do so while attending to near-term resetting and remanufacturing requirements. To do this, it must invest in and leverage the best that the domestic and international industrial base can offer and make effective use of emerging defense suppliers.

While the U.S. vertical lift industrial base has been focused increasingly on the remanufacture and refurbishment of legacy platforms, the way the Department manages demand in the next five years will determine the innovation in this industry through the middle of this century. The following table summarizes the key watershed events which the Department has available to shape this industrial base.

KEY WATERSHED ACQUISITIONS

Comanche	Provides opportunities to use funds for multiple competitions if the Light Utility and Armed Reconnaissance helicopter acquisitions are structured properly.
VXX[11]	Off-the-shelf acquisition strategy will not facilitate design innovation.
PRV	Most promising near-term opportunity to inject innovation into this sector—if missed, could commit the Department to 30 more years of legacy technology.
Armed Reconnaissance/ Light Utility helicopters	Off-the-shelf acquisition strategy for both the Armed Reconnaissance and Light Utility helicopters will do little to facilitate design innovation.
Heavy lift helicopters	The demanding requirements for this class of aircraft will require the Department to reinvest in vertical lift technology which will go far in continuing U.S. heavy lift supremacy.

Source: ODUSD(IP)

[11] VXX could provide an initial innovative spark to be used in Personnel Recovery Vehicle (PRV), but its off-the-shelf acquisition strategy makes this highly unlikely. The VXX program acquisition strategy calls for the modification of an existing medium-lift helicopter capable of incorporating Presidential transportation and command and control needs. The desire to accelerate the program limits the Department to two competitors—a U.S. supplier and a U.S./off-shore joint venture, both using existing technology. As currently structured, the 23 aircraft purchase will do little to stimulate innovation within the U.S. industrial base and may not provide the winner of VXX any particular advantage in the follow-on Personnel Recovery Vehicle (formerly the Combat Search and Rescue (CSAR) helicopter) competition in the 2005 timeframe.

We recommend the following measures to ensure innovation of the vertical lift industrial base as we move away from the interlocking structure of legacy suppliers and through the watershed between platform-oriented concepts to the system-of-systems that undergird the functional concepts of 21st century warfare. Specifically, the Department should:

1) Fund the development of concepts that exceed current capabilities. Focus and invest in heavy lift as a possible family of capabilities for FCS and Sea Basing that draws on as wide an array of suppliers as possible. Consideration should be given to forming a joint program office and structuring acquisitions in a series of competitive awards. At present, heavy lift is a technical capability in which the U.S. industrial base still excels. Heavy lift innovation in the U.S. vertical lift industry will need to be nurtured and improved to meet future challenging demands.

2) Leverage near-term program and maintenance support decisions to enhance innovation in this industrial base by promoting innovation at every opportunity. This involves not repeating the paradigm of sole sourcing follow-on and support contracts to legacy suppliers, as well as resisting the temptation to procure existing platforms where innovative approaches available in the industrial base could yield enhanced capability—potentially at less cost. Additionally, industrial base impacts should be a consideration in the development of acquisition strategies.

3) Sustain the U.S. lead and continue to leverage tilt-rotor technology, which may in turn reinforce and cross-feed heavy lift concepts. Tilt-rotor is a truly revolutionary technology with the potential to change the future of this sector in manned and unmanned applications.

4) Make use of innovative proposal evaluation criteria as another means of shaping the industrial base.

    - The Department continues to recognize the importance of visible, demonstrated, and continuous improvement in process capabilities, system capabilities, and product and supply chain management. If the Department's policy is to have industry manage and report by Enterprise Resource Planning (ERP) that enables visibility into the contractor's production operations, then each acquisition program should incorporate evaluation criteria to measure each offeror's capability to be responsive to these requirements. Since computer automation is implied in these tools, companies would be forced to improve their computer design tools, advanced planning hardware and software, computerize shop floor reporting processes, or run the risk of being evaluated as non-responsive to the program requirements. Such criteria would also motivate industry to accelerate the implementation of lean manufacturing practices given that the key management information systems would be in place to meet

evaluation criteria. To accomplish this, DoD acquisition policies and procurement practices must be structured to be mutually supportive of each other.

- Ambitious readiness standards should also be made part of all follow-on, support, and new aircraft acquisition strategies. Warfighters dependent on vertical lift should not be forced to work around readiness standards a fraction of those typical in the fixed-wing community.
- System-of-systems, functional capabilities and corresponding interfaces/synergies should be emphasized at every opportunity.

As a consequence, DoD competitions should evaluate each offeror's capability to be responsive to these requirements.

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AFTERWORD

It is our hope that this study of the vertical lift industrial base has provided a blueprint for action useful to the Department in its investment planning and acquisition strategy deliberations. We also hope that it serves to better align industry planning to the Department's goals for 21st century warfighting.

We benefited immensely from the wise counsel of the senior leadership of the Department and a broad cross-section of the vertical lift industrial base in their support of this effort and in their service as Red Team members reviewing this report prior to publication. In fact, the Industry Red Team asked to return imminently prior to publication to take a final look. As such, much collaborative learning and communication has already taken place among Department and industry leaders as a result of the publication of this study—although we hasten to add that Industry Red Team members wanted to be sure that their enthusiastic participation not imply endorsement or agreement with our conclusions!

As this study was underway, the striving for excellence on the part of the vertical lift industrial base continued. Sikorsky won the Canadian ASW helicopter competition with its H-92. Bell, even though it failed to achieve Navy EVM system certification, was able to attract a new CEO who is an industry leader brimming with enthusiasm for Bell's potential to graft its considerable commercial innovation to military requirements. Boeing was already well underway to having two world-class vertical lift manufacturing facilities.

As we look to the future, we are reminded that there are few challenges beyond the grasp of the ingenuity of American workers and warfighters. In fact, one of the distinctly unique characteristics of the U.S. defense industrial base is the unrelenting support of the warfighter by each and every production line worker in our defense industrial base. We are reminded of this in each study of the defense industrial base we undertake.

For example, the extraordinary impact that Aircraft Assembler Mark Madden had on turning around Boeing Philadelphia. He works in the Boeing CH-47 modification center in Philadelphia and reminds us all that there are few challenges that cannot be surmounted if well-intentioned Americans put their minds to it. In forming of the first Boeing Rotorcraft Employee Involvement (EI) Team, Mark took a leadership role that set a standard of excellence for all subsequent EI Teams established at Boeing. This concept empowered manufacturing employees to form working partnerships with management and take direct roles in formulating tasking, setting work schedules, and assuming oversight responsibilities for team member contributions. Mark's enthusiasm for the EI concept, his hard work, and result-oriented approach enabled all of his team members to improve their work efficiency and effectiveness from the start.

His team continues to "spread the gospel" in that facility and inspire by example. We know that we can count on the Mark Maddens in the vertical lift industrial base—and indeed, the entire industrial base—to provide the warfighter the innovative and imaginative new systems required for 21st century.

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ACRONYMS

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ACRONYMS

AERP	Automated Enterprise Resource Planning
AHS	American Helicopter Society
AMC	Air Mobility Command
AMCM	Airborne Mine Counter Measures
APB	Acquisition Program Baseline
APUC	Average Procurement Unit Cost
ARA	Acquisition, Resources, and Analysis
ASUW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
C4ISR	Command, Control, Communications, and Computers, Intelligence, Surveillance, and Reconnaissance
CAIG	Cost Analysis Improvement Group
CSAR	Combat Search and Rescue
DAES	Defense Acquisition Executive System
DCMA	Defense Contract Management Agency
DS	Defense Systems
EMD	Engineering and Manufacturing Development
EPP	Enhanced Planning Process
ERMP	Extended-Range Mission Payload
ERP	Enterprise-wide Resource Planning
ESG	Equipped Shelf Group
EVM	Earned Value Management
EVMS	Earned Value Management System
FAA	Federal Aviation Administration
FCS	Future Combat System
FMS	Force Modeling and Simulation
FYDP	Future Years Defense Program
GPS	Global Positioning System
IDS	Integrated Deepwater System
JSF	Joint Strike Fighter
JSTARS	Joint Surveillance and Target Attack Radar System
JTRS	Joint Tactical Radio System
JVATF	Joint Vertical Airlift Task Force
LRIP	Low Rate Initial Production
LUH	Light Utility Helicopter
MBB	Messerschmitt Bolkow Blohm
MCH	Multi-mission Cutter Helicopter
MDAP	Major Defense Acquisition Program
MIS	Management Information Systems
NASA	National Aeronautics and Space Administration
NSW	Naval Special Warfare
ODUSD(IP)	Office of the Deputy Under Secretary of Defense (Industrial Policy)
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom

PA&E	Program Analysis and Evaluation
PAUC	Program Acquisition Unit Cost
PIP	Program Improvement Plan
PM	Program Manager
PMAA	Primary Mission Aircraft Authorization
POM	Program Objective Memorandum
PRV	Personal Recovery Vehicle
R&D	Research and Development
RDT&E	Research, Development, Test, and Evaluation
SAR	Search and Rescue
SDD	System Development and Demonstration
SUAV	Small Unmanned Aerial Vehicle
TBD	To Be Determined
UAV	Unmanned Aerial Vehicle
USD(AT&L)	Under Secretary of Defense (Acquisition, Technology, and Logistics)
VERTREP	Vertical Replenishment
VIP	Very Important Person
VOD	Vertical Onboard Delivery
VUAV	Virtual Unmanned Aerial Vehicle